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PROVISIONAL SPECIFICATION

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Invention Title: **Fruit products.**

The invention is described in the following statement:

FRUIT PRODUCTS

FIELD OF INVENTION

This invention is concerned with processes for the production of fruit products, particularly dried or semi-dried fruit pieces.

The goals of fruit preservation are to establish microbial and chemical stability and a desirable organoleptic character of the food which allow the product to be consumed both in and out of season. Methods have evolved empirically such as sun drying, forced air drying, salting and sugaring of fruits and these foods have subsequently become key components in a multitude of processes used throughout the world. Apart from dessert usage, preserved fruits are now widely used in the cereal, snack food, baking and dairy industries.

An important factor in the production of dried or semi-dried foods is to ensure that the available moisture or water activity (Aw) in the fruit is low enough to inhibit microbial growth during storage. The water activity of a food is defined as the partial pressure of water in the food divided by the saturation pressure of water at the same temperature. Low Aw's have been achieved in fruit by the reduction of the moisture content of the fruit below the critical level needed to sustain microbial growth. Upon storage however, these fruits may undergo further losses in moisture and chemical reactions may occur which result in undesirable changes in the colour, flavour and textural properties, leading to a hard, dry product which often has poor rehydration or eating properties. This is especially a problem when the fruit is packaged with dry food products like breakfast cereals which have a lower water activity than the fruit.

One approach to fruit preservation has employed the use of various edible humectants and sugars to achieve microbiologically stable intermediate moisture foods. Such foods are usually 15% to 50% moisture, have Aw's of 0.60-0.85 and remain soft and are stable at room temperature. These methods of moisture control in dehydrated fruits such as apples and raisins have involved either the addition of simple sugars like fructose and dextrose and/or polyols like glycerol in hypertonic solutions for osmotic

dehydration. Solute addition may require the use of a vacuum and/or subsequent traditional dehydration (US Patent 5,000,972; Nafisi-Movaghar, K, 1991). Such products do not require packaging in hermetically sealed containers, sterilization, refrigeration or freezing. For example US Patent 4,390,550 (Kahn *et al,* 1983) disclosed an invention in which the fruit was infused with sugar(s) to reduce the water activity to a range of 0.45 to 0.65 and depress the freezing temperature of the product.

Several drawbacks prevail in these methods such as the long times necessary to achieve solute infusion and the quantity of leftover infusion syrup produced which needs to be recycled in some way. The texture of products made by these methods is often substantially different from the fresh fruit. Although these products are of a low enough Aw to retard microbial growth, they are often of higher Aw than the foods of which they are components like breakfast cereals and flour mixes which are often at low Aw (0.1 to 0.2) and moisture content (1% to 2%). Subsequently upon storage, a displacement of moisture occurs from the fruit to the cereal, resulting in the undesirable hardening of the fruit and concomitant softening of the cereal.

Methods using a combination of osmotic dehydration and water activity control can be used either in addition to, or in place of traditional dehydration and vacuum drying (US Patent 3,952,112; Fulger *et al*, 1976). These processes are also slow and/or expensive. For example, US Patents 4,917,910 (Hseih *et al*, 1990) and 5,000,971 (Hseih *et al*, 1991) disclosed methods of increasing the amount of solute infusion into raisins and other fruits. A combination of mechanical tumbling of the fruit and liquid humectant addition was used which resulted in an Aw equal to 0.3 or less but this takes up to a month to attain.

Another method includes a pre-treatment of the fruit by blanching followed by infusion of solutes at elevated temperatures (US Patent 5,073,400; Bruno *et al*, 1991; US Patent 5,286,505; Hartson *et al*, 1994). However, these methods require from twenty four hours to several weeks to achieve high levels of humectant uptake and low Aw. It is

therefore desirable to reduce the time, cost and waste factors involved in processing dried fruits and at the same time maintain the optimal functional and organoleptic properties of the product.

It is an object of this invention to provide a rapid and simple process of introducing solutes into fruits in order to control or modify one or more of moisture content, water activity, colour, flavour and texture, whilst avoiding the aforementioned disadvantages associated with prior proposals.

SUMMARY OF THE INVENTION

In a first aspect this invention relates to a process for introducing solutes into dried fruit which comprises:

(a) providing dried fruit of desired moisture content;

(b) disrupting the structure of the fruit whilst maintaining integrity thereof;

(c) reacting the fruit with a solute solution for a time sufficient to allow solute infusion into the fruit; and optionally,

(d) removing any remnant infusion liquid and thereafter drying the fruit to a desired moisture content and water activity.

Preferably, the fruit is a dried fruit piece.

In a further aspect the invention relates to a process for preparing dried fruit containing solutes such as humectants, sugars, flavours, colours and preservatives, which comprises:

(a) subjecting dried fruit pieces of a desired moisture content to a regime which modifies the structure of the fruit piece;

(b) combining the fruit with a predetermined amount of a solute solution for a time sufficient to allow infusion of the solute into the fruit; and, optionally,

(c) removing any excess solute solution, whereafter the fruit may be dried to a specified moisture content and water activity.

DETAILS OF THE INVENTION.

Dried fruit of a desired moisture content is treated according to the processes of this invention so that it includes solutes which control or modify one or more of moisture content, water activity, colour, flavour and texture. The inventive processes allow rapid uptake of solutes into dried fruit with resultant processing benefits.

In a first aspect this invention relates to a process which comprises:

(a) providing dried fruit of desired moisture content;

(b) disrupting the structure of the fruit whilst maintaining integrity thereof;

(c) reacting the fruit with a solute solution for a time sufficient to allow solute infusion into the fruit; and optionally,

(d) removing any remnant infusion liquid and thereafter drying the fruit to a desired moisture content and water activity.

In a second aspect this invention relates to a process which comprises:

(a) subjecting dried fruit pieces of a desired moisture content to a regime which increases the surface area of the fruit piece;

(b) combining the fruit with a predetermined amount of a solute solution for a time sufficient to allow infusion of the solute into the fruit; and, optionally,

(c) removing any excess solute solution, whereafter the fruit may be dried to a specified moisture content and water activity.

The invention is concerned with the treatment of predried fruits that have been dried to a moisture content of about 5% to 30% or higher by traditional methods such as hot air drying, vacuum drying, freeze drying, or other methods which are well known in the art. Preferably, the dried fruit which may be treated according to this invention are

suitably sized fruit pieces. The size of the fruit piece depends upon its ultimate intended use, which may, for example, be as a breakfast cereal, snack food, or product for use in baking or dairy products.

Disruption of the structure of the fruit may take the form of an increase in the surface area of the fruit, and/or the disruption of the internal structure of the fruit, and/or the production of minute cracks on the surface or the edges of the fruit. Disruption of the internal structure of the fruit, or alternatively a regime which increases the surface area of the fruit, may be provided by passing the fruit through a roller mill, by explosion puffing (Sullivan *et al*, 1980, *Journal of Food Science 45*:1550-1558) or by other means. For the purposes of convenience, this invention will be further described with reference to a roller mill or explosion puffing, but it is to be understood that the invention is not limited to the use of these methods.

If a roller mill is used, a gap between the rollers of the mill is adjusted so that the piece of fruit is compressed and then released to such an extent that an increase in the surface area of the fruit occurs. The process of compression (for example, by rolling) and subsequent release of pressure may cause certain fruits to achieve an expanded or puffy texture. The disruption of the internal and surface structure of the fruit allows better access of an applied solute to intracellular spaces. The extent of rolling necessary will depend on the type of fruit, the size of the fruit or fruit piece, the moisture content, the temperature of the fruit at rolling and the amount and type of solutes that are desired to be introduced into the fruit. With some fruits it may be beneficial to warm them before rolling. If the fruit is too high in moisture, it may stick to the rolls and may be too plastic to achieve the required degree of disruption, and if the fruit is too dry, it may shatter and may produce a sub-optimal texture and unnatural appearance of the final fruit product. Whatever the method of physical treatment used, the fruit or fruit piece is maintained as an integral product which preferably maintains the overall shape of the fruit prior to treatment.

After treating the fruit as described above, it is then treated with a solution containing solutes such as sugars and/or other water activity controlling substances such as glycerol or sorbitol, which may or may not be preheated. The solution may also contain additional solutes such as fruit juices, flavours, colours, and preservatives to enhance the flavour, texture, and stability of the fruits. While an excess of solution may be added to the fruits it is preferable that the quantity of solution added be a predetermined amount that will be completely absorbed. The treatment of the fruit may be at ambient temperature, but the absorption rate is increased by elevating the temperature to 50°C to 60°C or even higher. During solute treatment of the fruit, gentle agitation may be used to ensure even mixing of the solutes into the fruits.

In order to avoid excess unabsorbed solution being generated, it has been found that the extent of compression of the fruit has an effect in controlling the amount and rate of solution uptake. As shown in Figure 1, using dried apple pieces as an example, the amount of solution absorbed by the apple pieces increased proportionally to a decrease in the gap width of a rolling mill. Thus the final fruit product yield (expressed as the fold increase in weight of starting dry fruit) increased with the degree of compression of the fruit. It was found that it is possible to add a predetermined quantity of solution to this rolled fruit and achieve total solution absorption thereby avoiding possible leaching of natural solutes from the fruit. It was also observed that at a very small gap width, the extent of rolling was excessive as judged by the resultant loss in the natural texture to the fruit.

After absorption of solutes, the fruits may require further drying, preferably to a specific desired moisture content and water activity, by for example traditional dehydration or by other suitable methods. Additionally, unabsorbed solution may be removed from the surface of the fruit by mechanical methods (for example by subjecting the fruit pieces to centrifugation), prior to dehydration. Any recovered solution may then be recycled for subsequent use.

The treated fruits may also be surface dusted with, for example, powdered sugar or other suitable materials to help ensure that the fruit pieces subsequently remain separate. The resultant products are soft fruit pieces which retain most of the original textural characteristics of the fruit and can be made to a wide range of controllable water activities, flavours and colours. Such treated dried fruits of very low Aw (0.20 to 0.35) are particularly useful for inclusion in breakfast cereals and cake and bread mixes where they will remain separate, soft and tender. They even remain soft and tender if included in frozen products. Higher Aw dried fruits can be included in formulations which may be further processed as in confectionery, muesli and granola bars. This invention is applicable to a wide range of dried fruits such as apple, pear, pineapple, sultanas, raisins, currants, prunes, blueberry, papaya, cranberry, banana, fig, peach, cherry, and the like.

Figure 2 sets out a preferred process scheme according to an aspect of the invention.

The process described above may be illustrated by the following non-limiting examples. Percentages are expressed on a weight basis and for each example, 100 g of start fruit material is used. Example 1 is indicative of a low water activity fruit which may be used in cereal or flour mixes and Example 2 describes a medium water activity fruit product which is applicable as a component of other formulations like baked snacks and cereals.

EXAMPLE 1

Low Water Activity Apple

Dehydrated apple dice (5 mm^3) containing 500 to 1000 ppm SO_2 (I), and at 20% moisture, were compressed by passage through a roller mill of gap width equal 10% of the average apple dice width. The resultant rolled apple dice (II) had a puffed and expanded appearance. A of solution (III) of weight equal to the rolled apple dice (II), which contained sucrose (57%), water (24.95), glycerol (17%), malic acid (0.7%) and

natural apple flavouring (0.35%) and heated to 80°C was added to the rolled apple dice. The apple and solution (IV) were combined by tumbling at 40°C to 50°C until the solution was absorbed, one hour. The apples were then dried (V) to 80% of the wet weight of (IV) by blowing hot air at 70°C to 80°C directly into the tumbling chamber containing the apples, taking thirty minutes. The apples were then dusted by tumbling with powdered sugar at 20% of this dried weight (V) and the resultant final water activity was 0.33. The final yield was a 98% increase on the starting dried apple (I) weight and the product was completed and ready for use in two hours.

Samples were packaged in laminated bags of aluminium foil and polythene in air and sealed and stored at room temperature and at 40°C. After three months of storage, the apples showed no signs of deterioration, had excellent colour and flavour and maintained more of the original soft texture and moistness characteristic of fresh apple. Storage of the treated apples of Aw = 0.33 with breakfast cereal which had a water activity of 0.24 for one month at room temperature, resulted in the fruit cereal mix having a water activity of 0.30. The cereal was still dry and crisp and the apple was still soft and moist with no change in colour or flavour. It was estimated that the product would have a shelf-life of about two years at ambient temperature.

EXAMPLE 2

Intermediate Water Activity Apple

Rolled apple dice (II) in Example 1 were combined with an equal weight of solution (VI) containing water (54.3%), sucrose (45.3%) and natural apple flavour ().45%). The apple and solution mix (VII) were tumbled at 40°C to 50°C until the solution was absorbed (one hour). The apples (VII) were dried to 75% of the wet weight of (VII) by blowing hot air at 70°C to 80°C directly into the tumbling chamber containing the apples which took thirty minutes. As an alternative, the apple/solution mix (VII) was dried to the same extent in a tray dehydrator with heated air at 70°C passing through the fruit product. The dried apples (VIII) were dusted by tumbling with powdered

sugar at 20% of the dried weight (VIII) and the resultant final water activity was 0.62. The final yield was a 98% increase of the starting dried apple (I) weight.

EXAMPLE 3

Apple Flavoured with Natural Blackcurrant Juice

Dehydrated apple dice (I) were treated the same way as in Example 1 except that the rolled apple (II) was mixed with a equivalent quantity of solution (IX) containing sucrose (44.2%), glycerol (26.6%), water (18.6%), blackcurrant juice concentrate of 68° Brix (9.9%), malic acid (0.13%) and citric acid (0.13%). The apple and solution combination (X) was mixed by tumbling as in Example 1 and subsequently treated in an identical manner as Example 1. The final yield was a 95% increase in the original dehydrated apple (I) used and the final water activity was 0.34. The flavoured apple had a natural blackcurrant flavour and colour with a soft moist texture.

EXAMPLE 4

Low Water Activity Pear

Dehydrated pear dice of about 5 mm three containing 500 to 1000 ppm SO_2 (XI), and at 20% moisture were rolled by passage through a roller mill of gap width equal to 42.7% of the dice width. An equivalent quantity of solution (XII) containing sucrose (42.8%), glycerol (38.2%), water (18.4%), citric acid (0.3%), and natural pear flavour (0.3%) at 80°C were mixed with the rolled pear dice by tumbling for three hours at 40°C to 50°C. The pear and solution mix (XIII) was then dehydrated to 80% of the weight of (XIII) as in Example 1. The dried pear (XIV) was dusted with powdered sugar at 20% of weight (XIV). The resultant yield was 71% of the starting dehydrated pear (XI) with a water activity of 0.34. The resultant pear pieces remained separate, were tender, and had a natural pear flavour and texture. Storage studies with low moisture breakfast cereal (Aw=0.2) for over one month at ambient temperature showed

no evidence of migration of moisture from the pear to the cereal. The cereal remained crisp and there was no change in the pear flavour, texture or colour characteristics.

EXAMPLE 5

Low Water Activity Raisins

Raisins of the size designated as "4 Crown" (XV) were dried at 80°C in forced air to a moisture content of 12.4%. The fruit was cooled and passed through a roller mill at a gap width of 2.8 mm. After passing through the roller mill, the raisins were slightly flattened and had numerous cracks through the skin at the edges of the flattened fruit. The raisins (XVI) were heated to 50°C and gently mixed for a period of sixty minutes with glycerol solution at 8% of the raising weight (XVI). During mixing the fruit was maintained at this temperature. After mixing, the product was cooled to ambient temperature and 25% by weight of powdered sugar was mixed with the raisins. The mixture was rapidly tumbled. The sugar formed a stable coating on the surface of the raisins. The fruit had a full globular appearance and were non-sticky and free-flowing. The water activity was 0.29. The fruit had a soft moist texture and maintained this on storage with breakfast cereal of a water activity of 0.20.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications which fall within its spirit and scope. The invention also includes all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations of any two or more of said steps or features.

Dated this 28th day of August 1995
BYRON AGRICULTURAL COMPANY PTY LTD
By its Patent Attorney
DAVIES COLLISON CAVE

Figure 1.

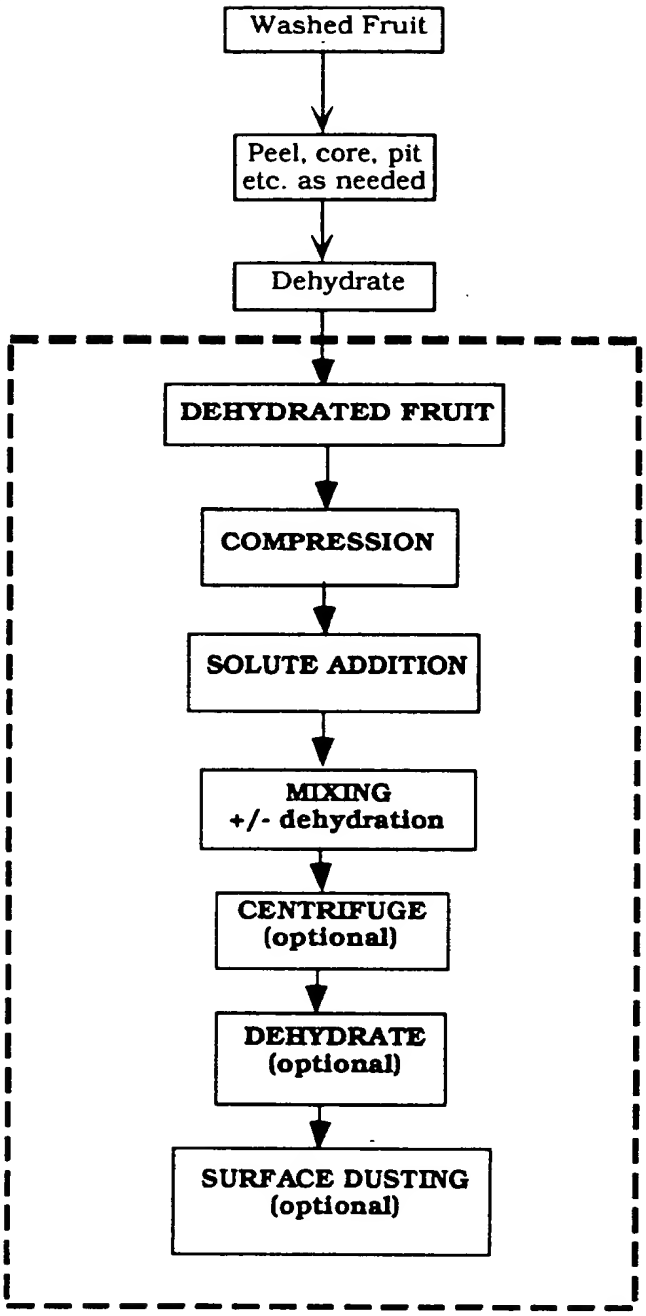
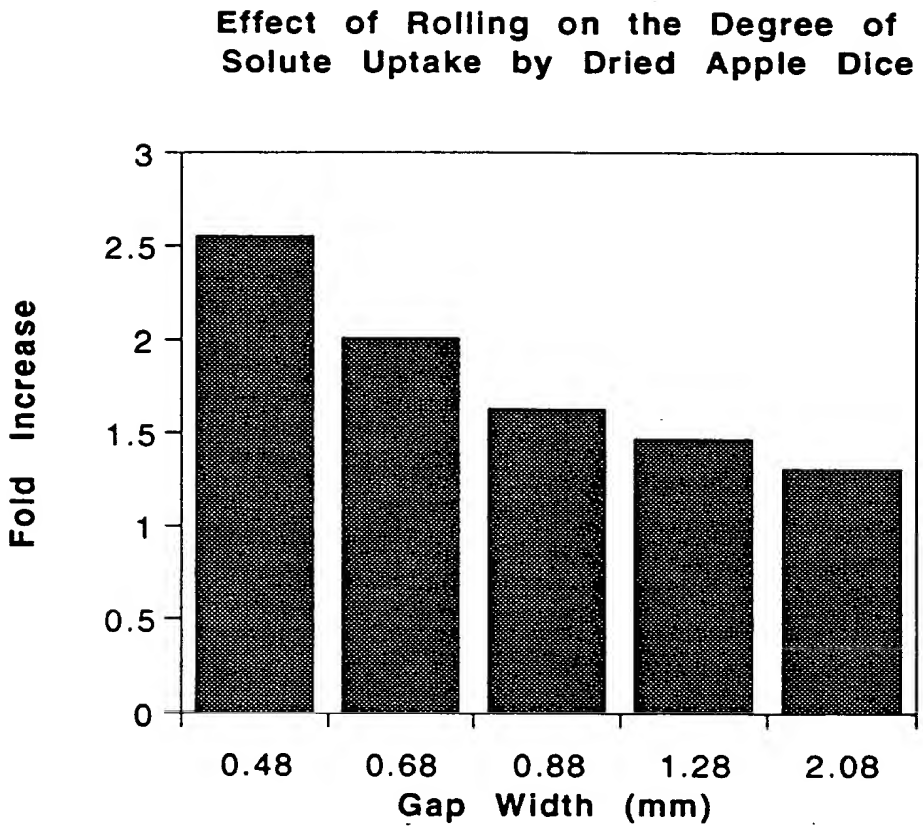

Washed Fruit
Peel, core, pit etc. as needed
Dehydrate
DEHYDRATED FRUIT
COMPRESSION
SOLUTE ADDITION
MIXING +/- dehydration
CENTRIFUGE (optional)
DEHYDRATE (optional)
SURFACE DUSTING (optional)

Figure 2


Effect of Rolling on the Degree of Solute Uptake by Dried Apple Dice
Fold Increase
3
2.5
2
1.5
1
0.5
0
0.48
0.68
0.88
1.28
2.08
Gap Width (mm)